

Performance of Bandwidth Enhancement Technique on Coaxial Probe fed Dielectric Resonator Antennas

Neeraj Kumar, Ajay Kumar Thakur

Abstract - This paper presents a comparative study of bandwidth enhancement techniques applied to a synthesized Compact Dielectric Resonator Patched Antenna (DRPA). Dielectric Resonator, itself has a good radiating power factor, which contributes to the advantages of proposed antenna system. Different techniques such as patching and perturbation of volumetric resonator source have been applied; which modify the radiating structure without contributing to the volume or area of the system. The performance of the antenna has been optimized to obtain good radiation efficiency and improve radiation pattern so as to enhance the directivity and the gain of the antenna. Theoretical performance of the proposed antennas are verified by full-wave simulations and experimental data obtained from a prototype. These results obtain verify the use of proposed antenna in different frequency of operation; this will make the suitability of antenna in frequency hopping technique. The obtained performance of proposed design, confirms the practicability of antenna in different indoor/outdoor wireless applications.

Keywords – Rectangular Dielectric Resonator Antenna, Co-axial Probe, impedance bandwidth, VSWR, Gain.

I. INTRODUCTION

Today, there is huge demand of data rate for efficient wireless communication. Modern Antenna should be capable to handle this huge demand of Bandwidth without compromising with the antenna characteristics such as VSWR, Gain, radiation Pattern and many more. It can be achieved by operating the wireless mobile systems at the millimeter wave frequencies [1-2]. Since 1991, Dielectric Resonator Antennas (DRA) are being preferred over the conventional micro-strip antennas because of its features such as small size, low cost, good bandwidth, high gain & Low ohmic loss. Dielectric antennas are gaining popularity in research field. The DRA can be used at millimetre frequency bands and they are available in basic shapes such as rectangular, cylindrical, spherical and hemispherical geometries. One of the main advantages of the DRA is its high degree of flexibility and versatility, allowing for designs to suit a wide range of physical or electrical requirements of varied communications applications. There are different techniques of feeding antennas and four most popular techniques are coaxial probe feed, micro-strip line, aperture coupling and proximity coupling [3-4].

The proposed study has been performed by designing two antennas; Antenna 1 and Antenna 2, which are designed on the basis of bandwidth enhancement techniques. “Antenna 1” has patching whereas “Antenna 2” has perturbation in radiating volumetric source. Co-axial probe fed technique is used to excite these proposed structures. Coaxial probe fed; it is a feeding method in which the inner conductor of the coaxial is attached to the

radiating element of the antenna while the outer conductor is connected to the ground plane. [5-9]

II. CALCULATIONS

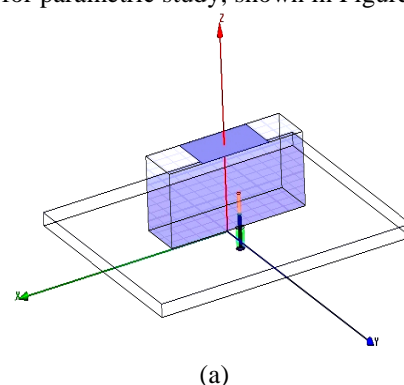
Basic rectangular shape of dielectric resonator has been performed theoretically on MATLAB software, where the mathematical equations were solved to get the desired dimensions of radiating structure of antennas for TE_{11}^x mode, resonant frequency of 2.5 GHz, VSWR of 2, relative permittivity of resonator as 15. Minimum to maximum value of w/h and d/h is 1 (ratio) 3, where ratio is w/h or d/h. Result obtained for the selected mode is presented in Table I.

Table I Dimension of RDRA obtained on Matlab

W (cm)	D (cm)	H (cm)	Q-factor	BW (%)
1.784	5.352	1.784	6.93	10.2

III. PROPOSED DESIGN

The proposed design uses a substrate of material Rogers RT/Duroid 5880 (tm) having relative permittivity of 2.2 and dimension 10 cm X 9 cm X .32 cm. The upper surface of the substrate has finite conductivity layer. This has been done to minimize the backlobe radiation. The rectangular dielectric resonator of relative permittivity 15 is used, having dimension of 5.352 cm X 1.784 cm X 1.784 cm. The top surface of the dielectric resonator is perturbed by embedding a strip of thickness 0.01mm. This structure is termed as “Antenna 1”, shown in Figure 1 (a). A perturbation in radiating material has been designed by removing a portion of dimension 5.352 cm X 1.338 cm X 0.288 cm from it. This modified structure is “Antenna 2”, shown in Figure 1 (b). Antennas are excited using co-axial probe feed mechanism. Parametric studies of the antennas are done by varying the probe penetration length, l into the dielectric material of the resonator. The variation of the length is done from 0.5111 cm to 0.6111 cm in step size of 0.111 cm. Penetration Length, l designed for parametric study, shown in Figure 1(c).



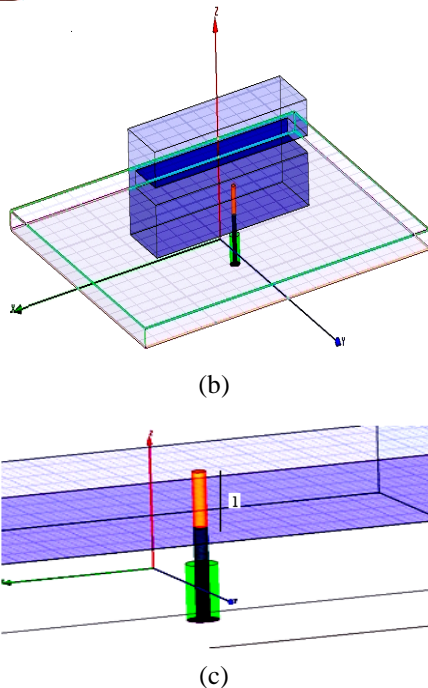


Fig.2. (a) 3D View of Antenna 1, (b) 3D View of Antenna 2 and (c) Parametric variation of Probe penetration inside the antenna as Project Variable, l

IV. SIMULATION RESULTS

The designed antenna is simulated on Ansoft HFSSv13 simulation software. The parametric variation of the project variable, l was done. The result obtained was studied in detail to know the optimum behavior of RDRA.

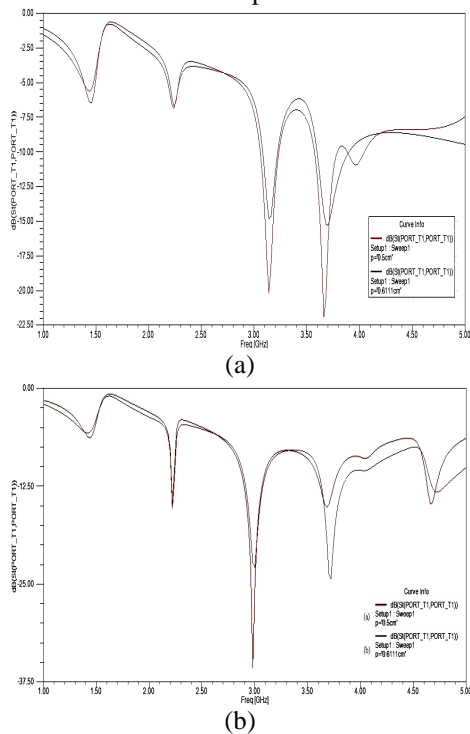


Fig.2. Return Loss graph (a) Antenna 1 and (b) Antenna 2; showing parametric variation of Probe length, l (a) l = .5111 cm, (b) l = .6111 cm

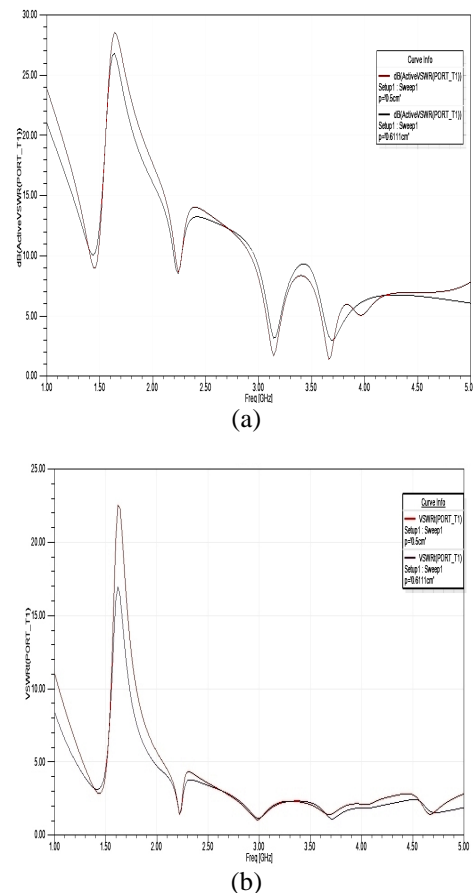


Fig.3. VSWR graph (a) Antenna 1 and (b) Antenna 2; showing parametric variation of Probe length, l (a) l = .5111 cm, (b) l = .6111 cm

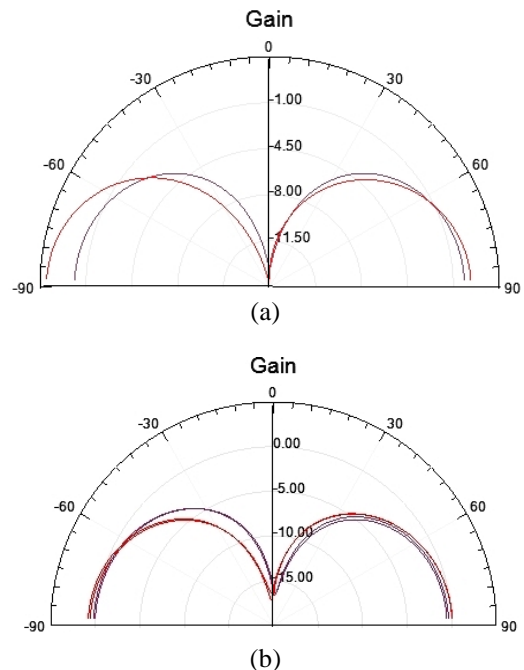


Fig. 4 Gain of antenna in terms of Radiation Pattern (a) Antenna 1 and (b) Antenna 2

V. DISCUSSION

As discussed in Section III, the parametric variation in the probe length, l was done by setting, l as project variable. The simulated Return Loss curve; VSWR curve and Gain of "Antenna 1" and "Antenna 2" have been presented in Figure 2, 3 and 4 respectively. From Figure 2, patching contribute dual frequency of operation for "Antenna 1" whereas perturbation offers good return loss at the resonant frequency for "Antenna 2". "Antenna 1" offers fractional impedance bandwidth of 36 MHz in frequency range of 3.06 GHz- 3.24 GHz and 3.60 GHz- 3.78 GHz, having resonant frequency of operations at 3.14 GHz and 3.66 GHz; and return loss of -20.20 dB and -21.90 dB respectively. "Antenna 2" provides impedance bandwidth of 30 MHz in frequency range of 2.84 GHz- 3.14 GHz, resonant at 2.98 GHz having return loss of -35.00 dB. During the variation of probe length, l was found to be 0.6111 cm.

From Fig. 3, VSWR values of the antennas are found to be in between 2-10 for "Antenna 1" whereas for "Antenna 2", it is 2-4; at the matching frequency of antennas, perturbation is advantageous. Gain of the "Antenna 1" and "Antenna 2" has been presented in terms of radiation pattern in Fig. 4, which is found to be 1.72.

VI. CONCLUSION

Different Bandwidth enhancement techniques have been applied on prototype antennas, Antenna 1 and Antenna 2; which are basically modified Rectangular Dielectric Resonator Antennas. Antenna is excited using co-axial probe which has advantage of easy fabrication; easy to match; low spurious radiation. A detailed parametric study of probe pin insertion into the volumetric radiating source is carried out to analyze the characteristics of the antenna. Ratio of probe pin insertion length, l ; to height of radiating source, h ; has been obtained 0.34. With proper design it is observed that the resonance of the probe and that of the dielectric structure itself may be merged to achieve extremely wide bandwidth over which the antenna polarization and radiation pattern are preserved. The proposed study shows patching and perturbation gives mixed response. Return Loss and matching is efficient with perturbation while patching gives dual frequency of operation as well as large bandwidth in comparison to perturbation. Gain of the antenna shows minute variation. The simulated antennas can be used as a suitable candidate for different indoor/outdoor wireless applications. Future aspect of the project is to study these two bandwidth enhancement technique on a single prototype and make comparison between them.

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AUTHOR'S PROFILE



Neeraj Kumar

a M.Tech. First year student in faculty of Telecommunication System Engineering at Amity Institute of Telecom Technology and Management, Amity University, Noida, India. His current research interests include dielectric resonator antennas, Meta-materials and Electromagnetic Wave Propagation.

Mr. Kumar is a recipient of Best Research Paper Award in the section of Information & Communication Science and Technology at 99th Indian Science Congress, KIIT University, Odisha, India, Student Prize Awards in Mobile & Embedded Technology Conference 2011, Amity University and Excellence in Knowledge Creation Award for Session 2008-2012 at Amity University, Noida, India.



Thakur Ajay Kumar

born in Darbhanga, India, received M.Sc. degree in Physics with specialization in Radio Physics and Electronics from L. N. Mithila University (L.N.M.U), Darbhanga in 1993. He did his Ph.D. degree on the topic "Generation of Time Domain

SC Network and study of their performance" from L.N.M.U, Darbhanga in 2006. Dr. Thakur has published more than 40 papers in national and international journals and more than 30 papers in conferences and seminars. He is a member of editorial board of the Indian Journal of research ANVIKSHIKI bi monthly international Journal of all research and STM Journal of Physics. A sectional committee member for Physical Sciences for 99th session of Indian Science Congress Association, Mr. Thakur is also member of different research organization / associations (ISCA, LASSI, and RESEARCH GATE & IEAN). He has organized a national seminar sponsored by University Grants Commission, New Delhi as a joint organizing secretary.

Dr. Thakur is recipient of best research paper technical award in 98th India Science Congress Conference, 2011 held at SRM University, Chennai, India. He has received best poster presentation award in National Seminar Sponsored by University Grants Commission (UGC), New Delhi and Award of Excellent Performance for his contribution to research work and other extra activities at C. M. Sc. College, Drbhanga. Currently, he is engaged as Project Fellow in Major Research Project, in the Dept. of Physics of C.M.Sc. College, Darbhanga, sponsored by UGC, New Delhi, where he is working for the improvement of broadband of compact dielectric resonator antenna in the area of technology innovation for the emerging information and communication technology (ICT) for socio-economic development. His current research interest is antenna technology and Nano antenna technology.